Modeling interactions between tectonic and surface processes in the Zagros Mountain, Iran

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Introduction

Fold and thrust belts record a variety of landscape forms (e.g. wind/water gaps, diverted rivers), and sedimentary features (e.g. alluvial fans, growth strata), reflecting the competition between tectonics and surface processes. Moreover, this competition plays a key role in the distribution and behavior of fluvial systems and thus affects both the transport and the deposition of sediments from mountains to basins.

Over the past decades, numerous models have been developed to study interactions between tectonics erosion, sedimentation and deformation. However, only a few models are using a fully 3D mechanical representation of the deformation and many issues remain unsolved. For instance, what control does an array of growing folds exert on drainage network development and, conversely, how does river incision influences growing structures? Which physical parameters are essential in predicting and interpreting wind gaps and diverted river features?

Landscape evolution model

The approach taken here is based on Simpsons and Schlunegger (2003) and uses a nonlinear diffusion formulation, which is the simplest mathematical formulation to model erosional processes taking both hillslope and channel processes into account by assuming that the sediment discharge qs is given by

$$qs = k_0 S + cq^n S \qquad (1)$$

where k_0 is the hillslope diffusivity, c the fluvial transport coefficient, and n a power law exponent relating the sediment transport to the fluid discharge. qs, and q are the sediment and surface water discharges, respectively, and S ($=|\nabla h|$) is the local slope.

Governing equations:

The model is governed by a system of two equations with the two unknowns *h(x,y,t)* and *q(x,y,t)*, the topography and the magnitude of surface fluid discharge, respectively. The masses of moving sediments and surface water are conserved, which yields:

$$\partial h/\partial t = -\nabla.(\mathbf{n}qs) \tag{2}$$

and

$$\nabla.(\mathbf{n}q) = \alpha \tag{3}$$

where $\mathbf{n}$ (= $-\nabla h/S$) is a unit vector directed down the surface, and α the effective rainfall. Substituting equation (1) into equation (2), the system can be written as

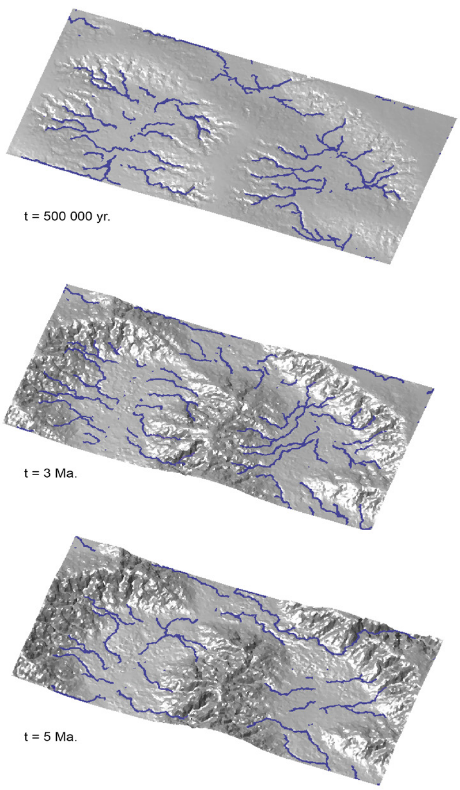
$$\partial h/\partial t = \nabla.((k_0 + cq^n)\nabla h) \tag{4}$$

where $k_0 + cq^n$ has the dimensions of a diffusion coefficient and

$$\nabla.(\nabla h/|\nabla h|) = -\alpha \tag{5}$$

The system is solved by the finite element method on an irregular triangle mesh. Equation (4) is discretized on 3 nodes triangle using linear shape functions and equation (5) is solved using a discrete water flow routing algorithm (also called D8 method). This method consists on routing progressively both sediment and fluid down the computed drainage area between discrete neighbors from the highest to the lowest elevation. This algorithm is computationally efficient but suffers from significant grid dependency.

Preliminary results



Velocities in z-direction, obtained from a 3D multilayer folding simulation of the thermo-mechanical code LaMEM were used as uplift rates in the landscape evolution model (Figure 1), to simulate the effect of more realistic uplift rates on erosion, without feedback of erosion to deformation.

REFERENCE

Simpson, G. & Schlunegger, F. 2003: Topographic evolution and morphology of surfaces evolving in response to coupled fluvial and hillslope sediment transport, Journal of geophysical research, 108, 7_{-1} – 7_{-16}